DOCUMENT RESUME

ED 043 375 PS 003 345

AUTHOR	Sulzer, Jefferson L.
TITLE	Behavioral Data from the Tulane Nutrition Study.
INSTITUTION	Tulane Univ., New Orleans, La.
PUB DATE	29 Dec 70
NOTE	23p.; Paper presented at the meeting of the American Association for the Advancement of Science, Boston, Massachusetts, December 29, 1970
EDRS PRICE	EDRS Price MF-$0.25 HC-$1.25
DESCRIPTORS	*Biological Influences, Data Analysis, Individual Differences, Intellectual Development, Longitudinal Studies, Measurement Techniques, *Nutrition, *Performance Factors, Physical Health, Preschool Children, Prognostic Tests, Psychological Testing, *Relationship, *Task Performance
IDENTIFIERS	Project Head Start, *Tulane Nutrition Study

ABSTRACT

Does nutritional deficiency retard psychological development? The Tulane Nutrition Study reports the first segment of its research based on extensive analysis of psychological and nutritional data gathered predominately on children who attended five, 6-week Head Start programs. Scores on a battery of eight psychological tests and two hematological measures (hematocrits and hemoglobin) provided baseline indices of psychological and nutritional status. Initial statistical tests failed to show differences that could be reliably interpreted as developmental retardation. Further analysis involved a pilot study in which dietary intervention produced an improvement in blood levels for the most deficient subgroup. No generalizations can be made until subsequent analysis (1) resolves issues raised by age, (2) controls for initial lack of equivalence in intervention groups, and (3) examines individual differences in nutrition and behavior profiles. Future research will focus on individual cross-sectional approaches and on follow-up studies involving selected children. (WY)

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

BEHAVIORAL DATA FROM THE TULANE NUTRITION STUDY

Jefferson L. Sulzer
Newcomb College, Tulane University

ED043375

In 1966, a survey of almost twenty-five hundred children enrolled in the summer Head Start program in New Orleans revealed that more than seven per cent had hemotocrits less than 33 per cent, levels which an expert committee of the World Health Organization classified as indicating presence of anemia. On the basis of this finding, Dr. Walter Unglaub, Professor of Nutrition at Tulane University, requested funds from the Office of Economic Opportunity to support a more detailed study of children and parents drawn from this population. Since his group was also participating in the Louisiana aspect of the National Nutrition Survey, ultimately they gathered a tremendous amount of data concerning clinical, biochemical and nutritional status of these subjects. For several years some of the psychologists at Tulane had conducted research on learning under local grants from the Head Start Center for Evaluation and Research. Ordinarily, our psychologists stay pretty close to their own level of analysis; however, when we learned early in 1968 of the Nutrition proposal, we made plans to coordinate our research efforts so that we might study the relationship between nutritional factors and behavior. My report here today is based upon behavioral measures gathered in the first phase of this research. During this period, a variety of analyses have been conducted which were designed to exhaust available data potentially bearing on the relationship between iron anemia and psychological

PS003345

This paper was read in the symposium, "Malnutrition and Learning in Children Within the U.S.A.", at the meeting of the American Association for the Advancement of Science, Boston, Mass., December 29, 1970.

performance variables. Although certain analyses were specified in advance, full exploitation of the data sometimes required methods of analysis which were frankly exploratory. In the process of examining the relationship between nutritional factors and psychological variables we have been acutely aware of the social implications of this research; however, I hope that this awareness has not blinded us to the necessity of maintaining scientific objectivity.

METHOD

The clinical, biochemical, and nutritional procedures utilized by the staff I will refer to as the "Medical Team" were, to a large extent, determined by fairly well-established precedent and the requirements of the National Nutrition Survey. The problem of selecting suitable behavioral measures was an entirely different matter. Our own inexperience in collaborative research of this nature was certainly a major disadvantage, but equally important was the fact that few standardized instruments have been developed for studying the behavior and psychological development of the population of children from which Head Start participants are selected. Partly, this is because it is generally difficult to develop reliable measures of behavior in any children under five; partly, it is because access to children participating in Operation Head Start is usually (and quite properly, perhaps) denied to behavioral scientists whose interests lie outside the more immediate goals of the program. In any event, the lack of suitable standardized measures and the paucity of methodological literature concerning research on nutrition and behavior provided us with less basis for making procedural decisions than is the case in planning most psychological research. Finally, in order to minimize the effects of our ignorance, we selected a number of measures

representing different kinds of psychological functioning, ranging from tests of intelligence and verbal behavior to measures of attentiveness and motor coordination. To insure that they were methodologically suitable for testing children in this population, some preliminary pilot work was undertaken with children drawn from an Education Improvement Project conducted in a predominantly Black school. On the basis of results of this pilot study, some measures were discarded and some procedures were modified. The final battery consisted of two intelligence tests, two measures of cognitive development, a short-term memory task, a group of reaction time tasks, a work of endurance measure, and a brief food-preference test. On about one-fourth of the subjects speech samples were also obtained.

Intelligence Tests

One of the two intelligence tests was the Van Alstyne Picture Vocabulary Test, which is composed of two sets of cards, each bearing four realistic line drawings of objects or figures. The subject's attention is drawn to the pictures and he is asked to point to a specific item, e.g., the box, the barrel, the girl who is drinking, etc. Scoring is based upon the total number of correct identifications made by the child. The test yields mental age and I.Q. measures based upon norms established with children from pre-school age through grade school. This test has an adequate split-half reliability and reportedly correlates fairly well with the Binet I.Q.

The other measure of intelligence, the Kahn Intelligence Test (1960), requires less verbal achievement since most of its items ask the subject to copy or complete behavior demonstrated by the examiner or to follow fairly simple instructions. Although this instrument is in an experimental form, it was chosen over better-established tests because it requires less

training and less time and space to administer it. The scale has sic items of graded difficulty in six-month steps at all age levels from infancy to fourteen years of age. Each item is scored pass or fail and it provides measures of mental age and I.Q., reflecting two-months credit for each item correct. The manual reports a reliability coefficient of .94 and a validity coefficient of .75, based on its correlation with the 1937 Stanford-Binet.

Measures of Cognitive Development

The two measures of cognitive development were specially developed for this project, although they were based upon earlier research. One of these was designed to provide information regarding the child's level of development with respect to moral judgment. This test was a refinement of a procedure used by Piaget (1932), in which the child indicates which of two stories describes the worse behavior. The extent to which he takes the actor's motives into consideration determines his level of sophistication in this judgmental process. The other test involved simple grouping behavior and was based upon a task described by Goldstein and Scheerer. In this task the subject was asked to group from three to nine objects which varied in form and color. Suchman and Trabesso (1966) have reported that a transition from color to form preference is a correlate of cognitive growth, therefore, a measure of form preference might reflect a higher developmental level.

Reaction Time Tasks

The first two groups of tests were included to provide data concerning different types of cognitive functions, more or less susceptible to the effects of explicit and implicit verbal achievement. The reaction time tasks were designed to provide measures of attentiveness and simple learning requiring minimal verbal comprehension and transfer from previous experience.

Three different reaction time tasks were run on the same apparatus which presented the subject with a vertical console containing four panels in a horizontal line and four panels in a square beneath them. Each panel could be lighted independently and reaction time was measured by electric timer from the onset of the light to the offset when the appropriate panel was pushed. On the first task, simple reaction time, only one of the lower panels was lighted and the subject simply pressed it as fast as he could to turn off the light. On the second task, disjunctive reaction time, one of two lower panels might be lighted and the child pressed as rapidly as possible to turn it off. The final task provided a measure of simple paired-associate learning and reaction time. In this task, the subject had to learn to associate one of the lower response panels with one of the stimulus panels in the horizontal row. Reaction time was measured from the onset of the stimulus light (which illuminated a drawing of a familar object) until the subject pressed the correct response panel, which lighted up to provide feedback. The child was given three training trials to learn each of the four associations. The examiner then quickly reviewed the relationships and administered three test trials for each association in scrambled order. The number of errors and reaction time during training and test trials were recorded, so that results could be analyzed by panel or by blocks of trials.

Cranking Task

One other major task on which most of the subjects performed provided a measure of endurance and incentive motivation. The apparatus was built from an unused surplus Gibson Girl radio transmitter, designed for use by downed aircraft pilots to signal for assistance. By turning the crank of this transmitter, an electrical voltage was generated by a magneto. When

PS 003345

modified, the output tripped a relay which activitated a timer recording total time of cranking at (or exceeding) the required rate of about one revolution in 1.5 seconds. A counter recorded total number of revolutions cranked. To provide an incentive for our young subjects, the apparatus was mounted in the belly of a colorful plywood clown whose eyes and nose lighted up when the requisite cranking rate was reached. The task was demonstrated by the male examiner who then challenged the subject to keep the clown lit up as long as possible.

Other Measures

Other measures were made which will not be considered in detail in this report. They were an attentive recall task involving short-term memory for pictured objects, a speech sample which was scored on several grammatical dimensions, and a brief food-preference test using pictures of foods with relatively high and low iron content. Some behavioral data concerning child-rearing practices, evaluation of the Head Start program, and a short speech sample were also obtained from some of the mothers. Additional interviews were conducted with selected parents.

The behavioral testing team consisted of six female examiners, four white and two black, two white male examiners, one white male field supervisor, and one or two teenagers who delivered the children to the examiners and returned them to their classroom when the session was over.

Five public schools which were serving as Project Head Start Centers were selected from various areas of New Orleans to provide a fairly representative sample of the neighborhoods in the population. Testing was conducted in libraries, offices, and unused classrooms provided by the Center directors. Some psychological measures were obtained on approximately 450 children during the six-weeks summer session beginning in July, 1968. Although all of the

tests were given to about 100 children, testing was incomplete on most of them. The number of cases varied from a low of 83 on the speech sample and 250 on the moral judgment test to approximately 325 on the I.Q. and cognitive tests and 350 on the reaction time tasks. The medical team obtained clinical, biochemical and nutritional information on almost 500 children during the month of August in a very efficient operation that interfered minimally with the testing schedule. For this examination, children and their parents were bussed to the nursery school and psychological laboratories at Newcomb College, Tulane University.

RESULTS

Comparisons of measures obtained from the five Head Start Centers by parametric tests indicate that their age and sex distributions were virtually identical, and that there were no significant differences among the psychological measures. However, when the Centers were ranked on each measure it was found that one of them was rather consistently better than others in terms of its higher blood levels, family size, I.Q. scores and shorter latencies on the reaction time tasks. In most cases, the differences between the means of this and other schools were quite small but the suggestion of a relationship among these variables was encouraging. Because these differences were not significant by parametric test and because the fullest possible response range was desired, other comparisons were based on the data from all Centers combined.

Age Differences

The primary purpose of this study was to investigate relationships which are presumed to exist between nutritional status and a variety of measures of

performance. The analyses reported here are based primarily upon two hematological measures, hematocrits and hemoglobin, as indices of nutritional state. Although other nutritional data will be used in future work, it was felt that these measures offer advantages over less direct indices, such as height or head circumference, which presumably relate to protein-calorie malnutrition occurring at an early age. The psychological tasks utilized in this investigation were selected to privide an array of measures representing different abilities or types of psychological process, verbal and non-verbal intelligence, conceptual functioning, attentiveness, and motor behavior. The fundamental hypothesis upon which this study was based, is that nutritional deficiency retards psychological development. To demonstrate the validity of utilizing these particular behaviors to test this hypothesis, it is essential to demonstrate that they are acceptable measures of development, that is, that performance on these tasks improves with age.

The ages of the total sample ranged from about 53 to 67 months at the time of testing. Three roughly equal age groups were formed with minimal subject less to provide the comparisons between chronological age and the other variables. The performance of children of different ages was compared to ascertain the extent to which it is legitimate to interpret each score as an index of psychological development. Only on this basis can any relationship between hematological and behavioral deficiency be discussed in terms of retardation of a growth process. Without this demonstration of age relatedness, differences in performance might be viewed entirly as reflecting differences in motivation and attentiveness. The results of the comparisons indicated that most of the measures used in the present study have a strong developmental (or age-related) component. Among the weakest results in this respect were those on the moral judgment task, presumably because most of

these pre-school children were too young to display the judgmental sophistication required to make a high score. It is likely that an irregular relationship found between age and one speech measure (number of adjective used) might reflect the same kind of limitation. Among the most striking findings of the age comparisons was that while mental age increased over the three age groups, the I.Q. actually declined because the rate of mental age gain was slower than would be predicted on the basis of the norms provided with the tests. Other investigations have shown that the difference in I.Q. between disadvantaged and privileged groups increases with age, a fact which has been interpreted as indicating the cumulative nature of the deprivation effects. The striking feature of our results is that they show appraent decrement of significant magnitude over such a limited age range.

Performance of Anemic and Normal Children

In making the comparisons between the hematologically deficient and normal children, a decision of prime importance concerned the standards of anemia which were to be adopted. On the basis of the hematologic data provided by the medical team, the percentage of subjects defined as anemic was calculated for hemoglobin and hematocrits using both World Health Organization and Children's Bureau Standards. Under the WHO standards, 5.4 percent of the subjects had low hematocrit readings and 57.3 percent were deficient on hemoglobin. Under the Children's Bureau norms, one percent were deficient on hematocrits and 11.2 percent had deficient hemoglobin levels. For our first comparisons it was decided to use the WHO norms for hematocrits and the Children's Bureau standards for hemoglobin. This was done to maximize the number of subjects in the low or deficient cells without including too many subjects who were in the normal range. Obviously, in making the decison to

adopt the less conservative standard for hematocrits, statistical reliability of the comparisons took precedence over other considerations.

Within each of three age groups, subjects were further classified as normal or low on the group hematologic measures so that their performance could be compared. Statistical comparisons within age groups showed that the only differences between hematocrit groups which were significant was the Van Alstyne mental age and I.Q. and the Kahn I.Q. in the middle age group. The trend of the results in other cases showed superiority of the normals at all age levels, but the differences were quite small, in view of the size of the standard deviations. The relationships between the low and normal group's mental age and I.Q. for each intelligence test are displayed in Fig. 1. In the KIT (Kahn Intelligence Test) scores of the two groups are about equal at the youngest age but the normal children are clearly superior in the two older groups for both mental age and I.Q. Although both groups show an apparent decline in I.Q. with age, this loss is much less for the normals. The reason for the decline in I.Q. is clearly revealed in the top graphs, which show that the mental age difference does not match the difference in chronological age. On the average, over the nine-month age span, the oldest and youngest low hematocrit groups differ by only 1.7 months while the oldest normal hematocrit group is 4.9 months higher than the youngest. The increase in mental age for the Van Alstyne test was more nearly equivalent for the two groups (1.9 for lows versus 2.5 for normals) but the normal group showed consistent superiority in all age groups. These comparisons were based on the hematocrit levels of the subjects. The results of comparisons of children low and normal in hemoglobin also showed higher I.Q.s and mental ages for the normals, but the differences were much stronger for the Van Alstyne than for the Kahn Intelligence Test. Further analysis of these results is now underway to determine whether the hemoglobin and hematocrit groupings

include subjects in the low groups who are different with respect to verbal and performance skills.

Because results of these tests indicate that the deficient children might be less intelligent than the normal children, we would expect to find differences in tasks involving learning. The only task in the battery which appears to provide a suitable measure of learning is the Paired-Associate part of the Reaction Time task. In this subtask, the subject received successive training trials to associate the four response panels with lighted stimulus panels displaying pictures of familiar objects. At the conclusion of this training phase, all subjects were tested for their recall of these relationships on trials on which errors and latency of the correct response were recorded.

The two graphs at the top of the Figure 2 show mean reaction time for children with low and normal hemoglobin in the three age groups (indicated by roman numerals). The best overall performance was produced by the oldest group of low hemoglobin subjects and the poorest performance by the two younger low Hb groups. In contrast with this, the three groups of normal subjects revealed highly similar trends and displayed somewhat more regular improvement over the four trials. The graphs at the bottom of the Fig. 2 show that both deficient and normal hematocrit groups tended to improve over trials, but again the trends were more regular for the normal subjects. Thus the form of the curves rather than the overall level of performance seems to be the major difference between deficient and normal subjects on this task.

At the risk of over-interpreting the relatively small differences in these results, it is tempting to draw conclusions concerning underlying differences in psychological functioning. At worst these conclusions might

provide fruitful hypothesis for further investigation. Two major alternatives seem to present themselves: (a) the smoother progression of the normals reflects their superiority in learning ability, and (b) the irregular performance of the deficient groups reflects a lower level, or less sustained level, of motivation to perform this task. Factors such as basic differences in reactivity or short-term attentiveness between the deficient and normal children are ruled out by the fact that the anemic groups were as proficient as normals on the Simple and Disjunctive Reaction Time tasks. However, the fact that these two tasks appeared earlier in the battery and that they also demanded less learning on the part of the subject does not provide evidence favoring either of the alternatives stated above. That is, the lows might have become more tired or bored or less alert as the testing progressed or they may have had more trouble learning the required stimulus - response relationships. Although performance on some other tasks, especially the Sorting tasks and the two intelligence tests, might provide additional bases for deciding whether motivation is the prime factor, neither can provide a pure indication of progressive fatigue or decreased motivation because these tests become progressively more difficult. For what it is worth, I can report that the test administrators' comments on the subjects' general attitude, attentiveness, and cooperativeness revealed no striking differences between deficient and normal children. In current research, more extensive information concerning these factors is being sought from the children's teachers.

The foregoing results revealed differences in favor of the normal children in intelligence and associative reaction time; however, statistical tests failed to show that these differences could be reliably interpreted as developmental retardation. Except for the vocabulary test results, the

differences within age groups were rather weak. These comparisons were based upon separate consideration of subjects low and normal in Hb and HCT, with deficiency defined in terms of Children's Bureau and WHO norms, respectively. It might be argued that performance differences between deficient and normals could be amplified if we were able to increase the hematologic differences. With the subjects available, this could be accomplished by comparing the performance of the children who are closer to the bottom and the top of the hematologic distributions or by identifying subjects who are low on both indices of anemia to compare with normals. In one set of analyses the mean scores of subjects low on both HCT and hemoglobin were compared with the scores of subjects normal on both measures. The results indicated better performance levels for the normal group on every major variable. For the two intelligence measures, both I.Q. and mental age were significantly (p. .05) in favor of the normals. In addition, the last test trial of the Associative Reaction Time task and the overall measure for this same task showed significantly poorer performance (greater latency) for the subjects low on both hematocrits and hemoblogin. On the other Reaction Time scores and the Crank measures, differences in favor of normals were evident; however, these were not statistically significant. Generally, this method of grouping the subjects seems to increase the reliability of the behavioral differences, presumably because the "double low" criterion increases the reliability of their classification as iron deficiency anemics.

Iron deficiency anemia refers to the <u>current</u> status of the individual. Although these results show a relationship between blood levels and performance, no specific conclusions can be reached concerning the factors responsible for the relationship. They may reside in current and temporary factors such as distractivility or lowered motivation related in some way to the oxygen

supply delivered to the tissues. In much of the literature there seems to be an assumption that this kind of malnutrition is less important than that which occurs early in life, presumably because it is reversible. Physical height for age index is one of past malnutrition which has been used in studies of psychological development and also in many surveys of national health as a barometer of dietary adequacy. The availability of anthropometric and hematologic data in the present investigation provide an opportunity to examine the relationship between these two indices of nutritional status and to evaluate their relationship to psychological development.

When subjects in the tallest and shortest quartiles were compared, we were somewhat surprised to find that the height comparisons produced differences on a larger number of performance variables than did the measures indicating a current state of anemia. At first, this seemed to indicate the residual effects of malnutirtion which had occurred at a more critical time in life with respect to potential effects on the brain. However, a failure to find a significant difference between the intelligence quotients of tall and short subjects suggested the need for further analyses. These results revealed that the taller group had significantly higher blood levels on both measures; thus, height apparently predicts present status in addition being useful as an index of past nutritional insult. The results also showed that the tall subjects were significantly older. Since the older subjects performed better on practically every task, this finding suggests that some of the relationship reported between height and psychological development might be due to the age factor. Further analyses are currently underway. However these results are sufficient to show the necessity of matching subjects for age - even when they are all in the same year of age.

In this study, we have seen that the relationship between performance

and hematologic status varied as the operational definition of anemia was changed. Figure 3 provides a comparison of performance on the Associative Reaction Time task, grouping the subjects on the basis of four different variables. Three of the variables are generally thought to be related; height, current hematologic status, and family size. The fourth variable, chronological age, is included to provide a basis for evaluating the magnitude of the differences in the other graphs.

An examination of these curves indicates that none of the variables relating to social class, growth, or anemia, controls as much of the variance as age does. In part, this is because the tasks in this battery were chosen for their age-relatedness. To an undetermined extent, however, the apparent weakness of the variables other than age stems from the fact that classifications based on them include subjects in the same group who might differ on other critical variables which can influence performance. In fact, this is the basis for some critics' pessimism about ever untying the variables involved in the relationship between nutrition and behavior.

Pilot Intervention Study

Some investigators have felt that they would be closer to establishing causal relations between nutrition and intellectual function if they could demonstrate intellectual improvement in subjects who receive a needed dietary substance. We are currently in the early stages of an investigation of this nature in cooperation with the Medical Team, and the Head Start Research Center at Tulane. However, the kind of problems encountered in this type of research are exemplified by results of some pilot work we did using some of the same Head Start children when they were in kindergarten.

Arrangements were made for the Medical Team to obtain biochemical data on

several classes of kindergarten children in the fall of 1968 and again in the Spring of 1969. During the period between, about half of the children consumed, under surveillance by the nutrition staff, a commercial cereal which is supposed to supply all or most of the minimum daily requirements of basic vitamins and iron. Because our primary blood measures were assumed to be indicators of iron deficiency, this dietary intervention study provided our first opportunity to carry out analyses which might reflect a stronger causal relationship between nutrition and behavior.

Originally, pre-treatment behavioral measures were to be obtained as soon as the hematologic determinations were available; however, delays in the scheduling made us decide to rely on the measures we already had on subjects who had been part of the summer Head Start investigation. This reduced the number of cases, but we felt it offered several offsetting advantages. Post-treatment performance data were gathered in May after the second blood measures were taken. To increase the number of children who could be tested in the limited time available, only the intelligence tests, crank, and reaction time tasks were used.

As a first approximation of a causal hypothesis, we might expect that if the fortified cereal could improve the blood levels, improvement might also be shown in the psychological measures. It is fairly well established that iron absorption, to some extent, depends upon the level of iron stores. Where the iron stores are adequate, the rate of absorption is relatively low; where there is iron deficiency anemia, iron absorption is likely to be higher (WHO, Technical Report Series, 1959, 182). Therefore, we felt that subjects whose blood levels were initially low should show grea-er change as a result of the dietary supplement than those whose blood levels were adequate. The mean hematocrit and hemoglobin levels of supplemented and nonsupplemented

groups are displayed in Figure 4. The two graphs at the top show that both supplemented and control groups with normal hematocrits in July showed lower levels in the following April. A comparison of the means for the two low groups shows that the supplemented group increased by about 2.75 while the control group retained its initially low level of HCT. The two lower graphs provide the same comparisons for hemoglobin. While both normal groups showed a slight increase and the low control group a slight decline, the supplemented subjects who were initially low increased dramatically. The results seem to provide fairly strong evidence that consumption of the iron-fortified breakfast cereal over a period of approximately eight months had a definite effect upon the blood levels of the subjects who were deficient in July. The stability of the blood level of the nonsupplemented low group indicates that this increase cannot be attributed to statistical regression, age-related improvement in diet or general health, or lack of reliability in the initial blood determinations.

Since the results seem to justify the conclusion that the dietary intervention produced an improvement in blood levels, we can now examine evidence concerning related improvement in the measures of psychological functioning. Unfortunately, the reaction time data were not yet analyzed at the time of writing this paper; however, mean I.Q. for the KIT and Van Alstyne tests are displayed in Fig. 5. The difference between the means for July and May provided the data for four one-way analyses of variance comparing each experimental group with the appropriate control group. The resulting F ratios had probability levels close to .05 in the case of the low group for the changes in the Kahn and Van Alstyne I.Q.. Although this seems to indicate that the supplement improved the deficient subjects' performance on these tests, an examination of the graphs shows that the supplemented lows'

I.Q.s were much poorer initially than the control lows. Looking back at the last figure, we can see that this was also true of the blood levels. A bit of detective work suggested that the differences reflect an attempt on the part of someone in the field to insure that the supplemented groups would include an adequate number of deficient subjects. Subject loss in the low control group might also have played a role. Whatever the cause of the initial lack of equivalence, it weakens confidence in the conclusion that the results reflect the effects of the dietary supplement. As a pilot study, however, it was successful in that it provided information which is useful in designing further intervention research. Incidentally, the results also demonstrated that the age differences in intelligence examined earlier do not necessarily mean that I.Q. must decline for these subjects. After a year of kindergarten the intelligence quotients had increased somewhat for all groups. Some of these same subjects will be tested again early in the coming year. It remains to be seen whether the differences we found in blood levels and in related psychological variables also undergo change. The positive relationship between height and blood levels suggests that some subjects who are currently anemic also experienced malnutrition earlier in life. Individual identification of these subjects will be required to ascertain whether their level of psychological functioning is less susceptible to change.

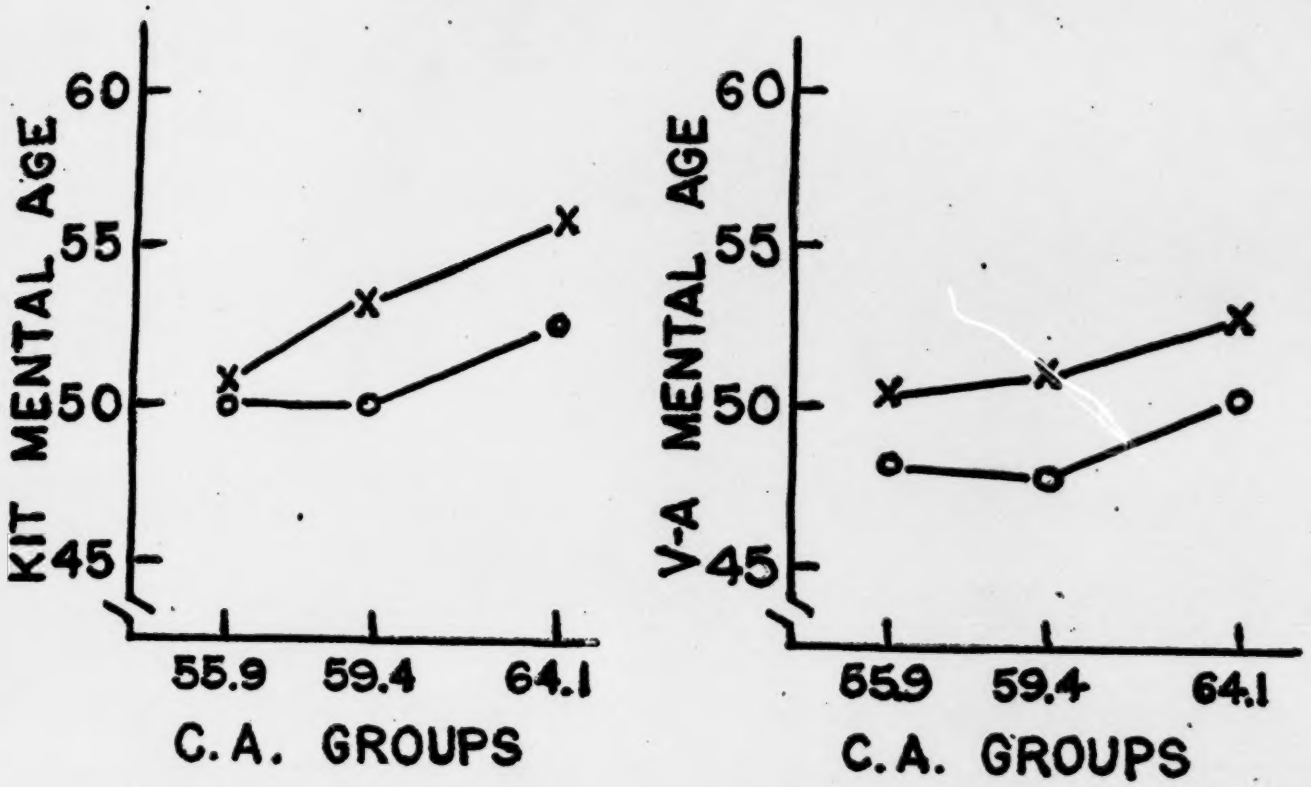
At this point in our research we are not ready to make generalizations with respect to the relationship between nutritional factors and psychological variables. Too much analysis remains to be done of data concerning the children's health histories and family situations, and relating their performance to biochemical variables other than those indicating anemia. The results I have reported on here have been based upon comparisons between groups of subjects; individual differences in nutrition and behavior "profiles"

have been ignored. Statistically speaking, these differences have been viewed as error variance providing a basis for evaluating differences between group means. In the analyses to be done, we will focus on these individual differences. For example, what differentiates the anemic child who performs poorly from the one with equally low blood levels who performs normally? Does the child who is below normal in height and blood level show a characteristic performance profile? With this kind of individual cross-sectional analysis and follow-up longitudinal analysis of selected children, we will be in a better position to draw more meaningful conclusions about the relationship between nutrition and behavior and to design more effective research to identify the mediating mechanisms.

Fig 1

HEMATOCRITS

o——o LOW x——x NORMAL



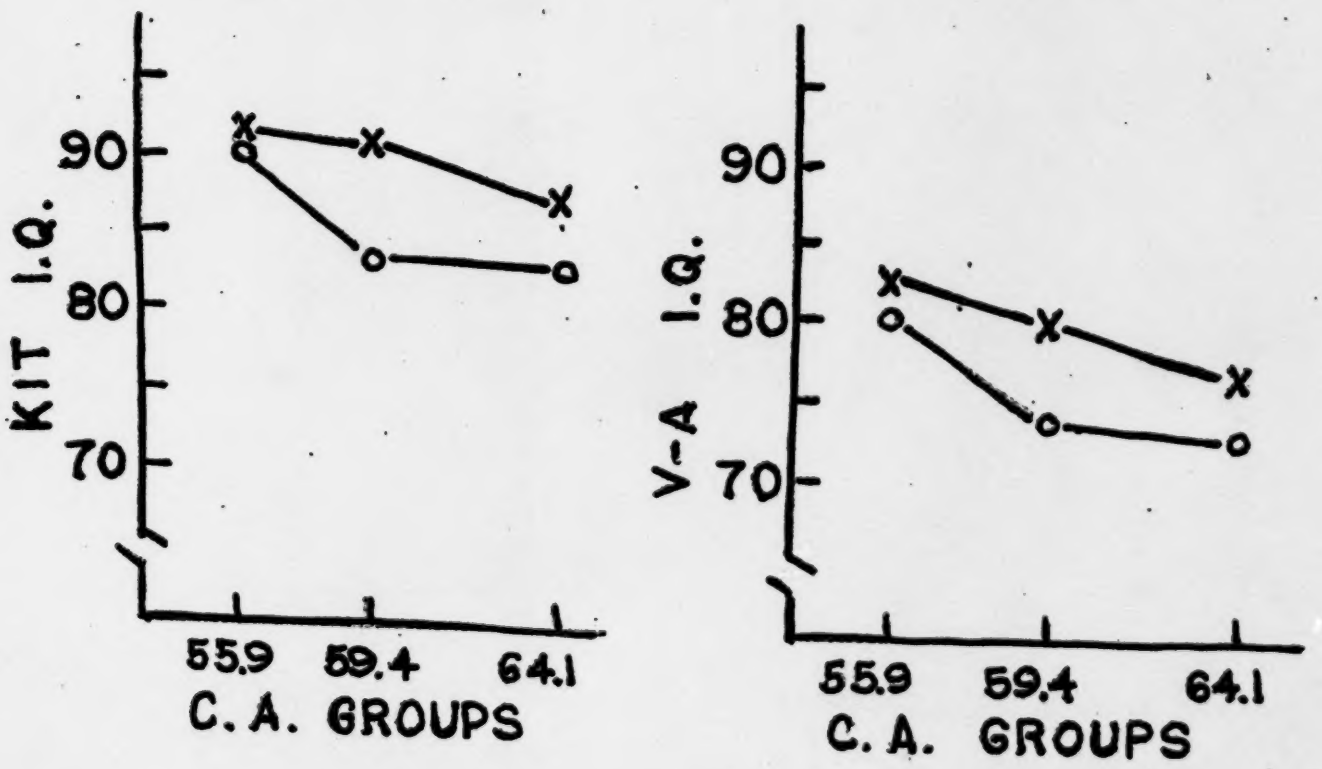


Fig 2

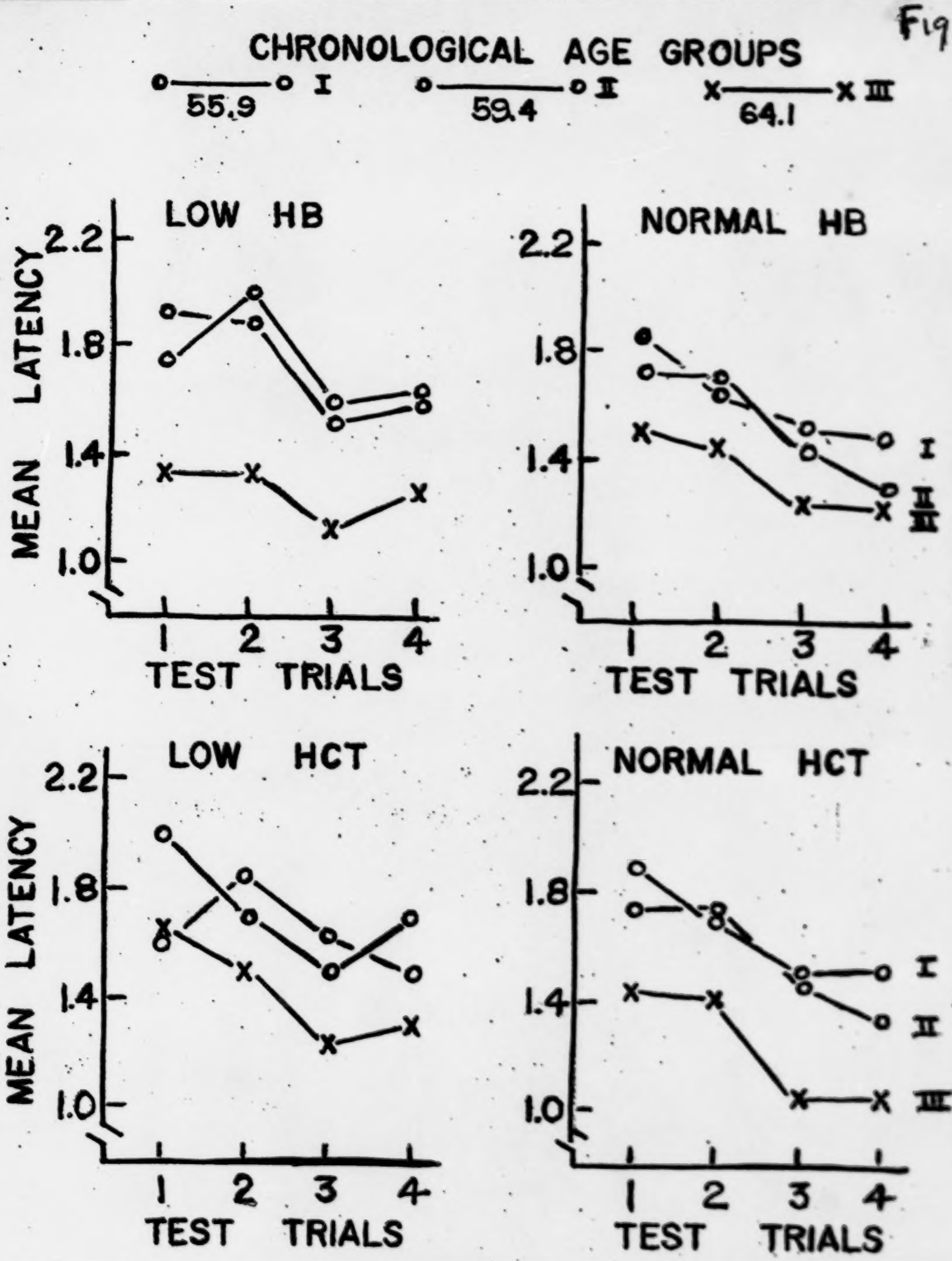
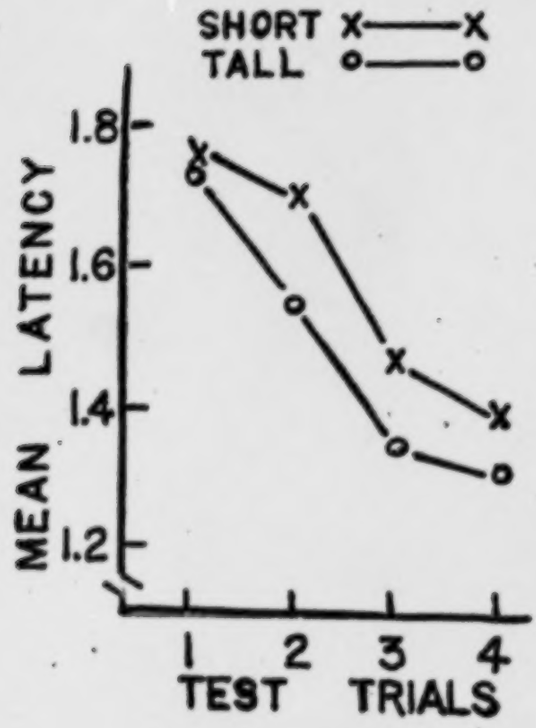
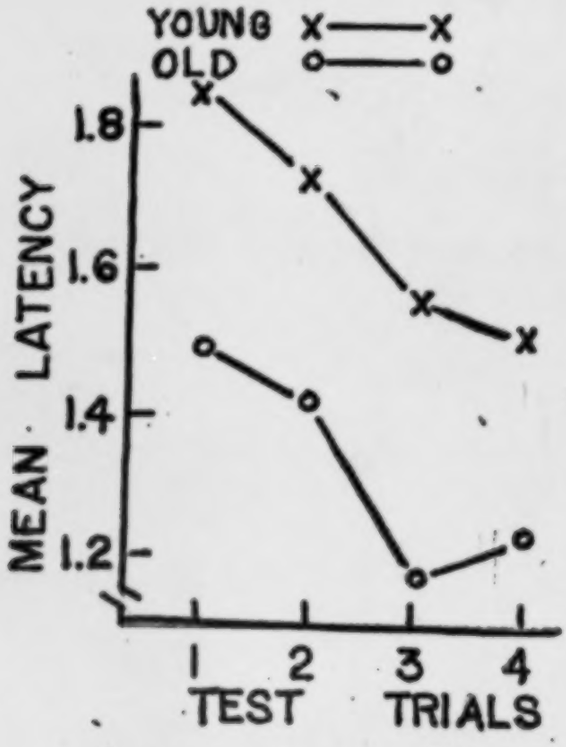
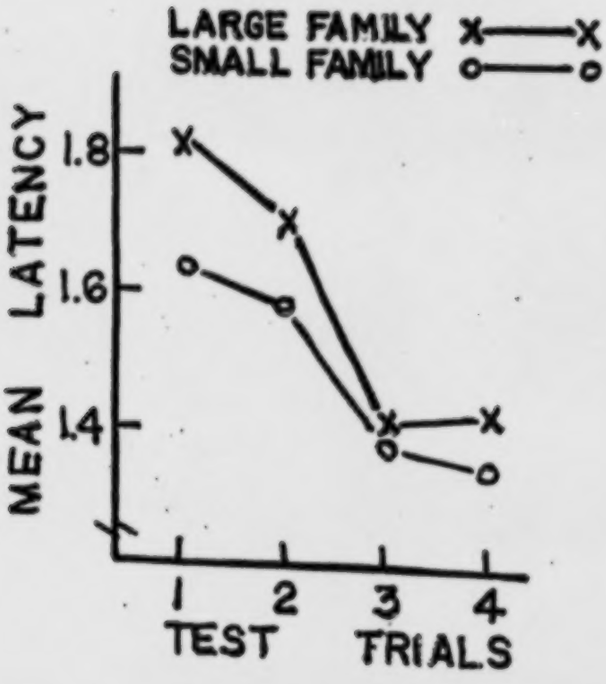
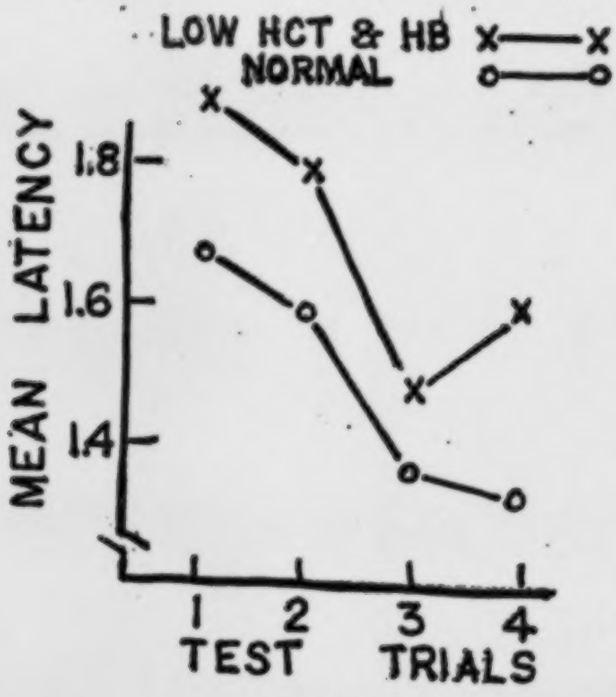

CHRONOLOGICAL AGE GROUPS
I
55.9
II
59.4
III
64.1
LOW HB
NORMAL HB
LOW HCT
NORMAL HCT
MEAN LATENCY
2.2
1.8
1.4
1.0
1
2
3
4
TEST TRIALS
I
II
III

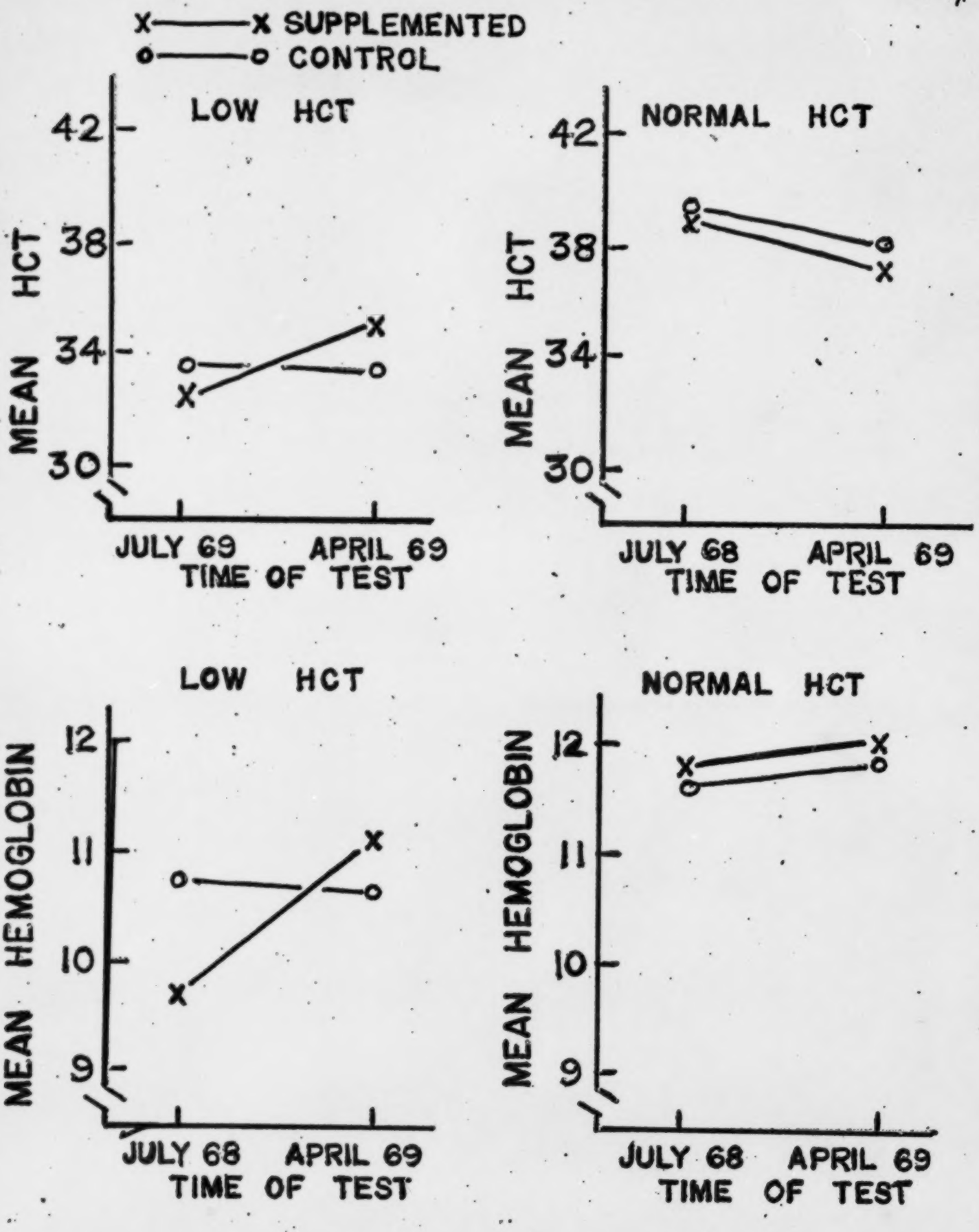
Fig 3


SHORT X——X
TALL o——o
MEAN LATENCY
1.8
1.6
1.4
1.2
1 2 3 4
TEST TRIALS


YOUNG X——X
OLD o——o
MEAN LATENCY
1.8
1.6
1.4
1.2
1 2 3 4
TEST TRIALS


LARGE FAMILY X——X
SMALL FAMILY o——o
MEAN LATENCY
1.8
1.6
1.4
1 2 3 4
TEST TRIALS


LOW HCT & HB X——X
NORMAL o——o
MEAN LATENCY
1.8
1.6
1.4
1 2 3 4
TEST TRIALS


X——X SUPPLEMENTED
o——o CONTROL
LOW HCT
MEAN HCT
42
38
34
30
JULY 69
APRIL 69
TIME OF TEST
NORMAL HCT
MEAN HCT
42
38
34
30
JULY 68
APRIL 69
TIME OF TEST
LOW HCT
MEAN HEMOGLOBIN
12
11
10
9
JULY 68
APRIL 69
TIME OF TEST
NORMAL HCT
MEAN HEMOGLOBIN
12
11
10
9
JULY 68
APRIL 69
TIME OF TEST